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SOQUEL-APTOS CREEK BASINS, SANTA CRUZ COUNTY, CALIFORNIA. PRELIMINARY REPORT ON FUTURE MUNICIPAL AND INDUSTRIAL WATER USES

Public Health Service
San Francisco, California

May 1963

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SOQUEL-APTOS CREEK BASINS

SANTA CRUZ COUNTY, CALIFORNIA

Preliminary Report
on
Future Municipal and Industrial Water Uses

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DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service Region IX
San Francisco, California

In Cooperation with the

DEPARTMENT OF THE ARMY
U. S. Army Engineer District - San Francisco, California

May 1963

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SOQUEL-APTOS CREEK BASINS

SANTA CRUZ COUNTY, CALIFORNIA

PRELIMINARY REPORT ON FUTURE MUNICIPAL AND INDUSTRIAL WATER USE

DEPARTMENT OF HEALTH, EDUCATION AND WELFARE

REGION IX

PUBLIC HEALTH SERVICE

DIVISION OF WATER SUPPLY AND POLLUTION CONTROL

SAN FRANCISCO, CALIFORNIA

May 1963

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INTRODUCTION

A. Purpose

The purpose of this report is to present projections of future municipal and industrial water use (to the year 2060) in the Soquel and Aptos Creek Basins and to examine some alternative sources of water supply for the area. The alternative water supply sources provide a basis for estimating the value of the municipal and industrial water stored in the proposed Soquel and Aptos developments by the alternative cost method.

B. Scope

The scope of this report is limited to an analysis of the available data. The forecasted water uses are based on economic projections furnished by the U. S. Army Corps of Engineers. The feasibility analyses of the alternative sources for value determinations are based on a consideration of water quality that could be provided. The report was prepared under a time limitation of sixty days after the receipt of the economic data from the Corps. The information presented in this report is, therefore, of limited scope and is intended to furnish information for preliminary planning purposes.

C. Authority and Request

At the present time, the U. S. Army Corps of Engineers is conducting a feasibility study on proposed water projects in the Soquel and Aptos Creek Basins in Santa Cruz County, California. These projects are primarily for flood control and water conservation. In a letter from the Corps dated March 22, 1962, the Public Health Service, Region IX, San Francisco, was asked to participate in these feasibility studies to the extent of developing projections

of future municipal and industrial water uses and determining the value of any water stored for municipal and industrial water supply. This study has been made in accordance with the Water Supply Act of 1958 (Public Law 85-500, Title III) and a Memorandum of Agreement between the Department of the Army and the Department of Health, Education and Welfare, dated November 4, 1958.

II. SUMMARY OF FINDINGS AND CONCLUSIONS

The following paragraphs summarize the pertinent findings and conclusions presented in this report.

A. Findings

1. Studies by the California Department of Water Resources show that there are limited quantities of poor quality ground water available in the Soquel and Aptos Basins, and the quantities that are available are not sufficient to meet future projected uses. The present source of most water supplies is ground water and the present use is approaching the safe ground water yield.

2. Existing records show that the Monterey Bay Water Company, which furnishes water to the towns of Capitola and Soquel, provides only minimum treatment (chlorination). The town of Aptos, which obtains its water from wells, has no treatment facilities.

3. At the present time, the firm of Brown & Caldwell, Consulting Engineers, is making an investigation for the City of Santa Cruz on the feasibility of incorporating the Aptos-Capitola-Soquel Area in its water service area.

4. The City of Santa Cruz is conducting or sponsoring studies to find additional water supply sources. The California Department of Water Resources reports in Bulletin No. 5 [1] that the City of Santa Cruz has filed for water rights for 16,000 acre-feet annually from Soquel Creek.

5. The water quality of the Soquel and Aptos Creeks is satisfactory for domestic use.

6. The water use for Capitola and Soquel is estimated at 84 gpcd. By comparison, the neighboring city of Santa Cruz has a reported water use of 160 gpcd. Differences in water use are attributed to limited capacity and

marginal quality of water in the Capitola-Soquel System, as well as possible differences in the economic characteristics of the two areas.

7. The growth potential of the study area is excellent. The already-completed Cabrillo Junior College and the new University of California campus at Santa Cruz, which will have a capacity of 27,000 students, will attract many new residents and probably new industry.

8. Recreation constitutes an important segment of the Santa Cruz County economy. The pleasant climate, natural attractiveness and proximity to a large population center will stimulate further growth in recreation facilities.

B. Conclusions

1. An increase in the water supply for this area appears to be necessary. The projections shown in Table 1 indicate a 9-fold increase in water use from 1520 acre-feet per year in 1960 to a use of 13,720 acre-feet per year in 2060. The present principal source of water supply (ground water) must be supplemented before 1980 to maintain adequate water service in this area.

2. The "net" amount of water that should be developed to supplement the present supply can be estimated as the difference between the "Total Water Use" and the estimated safe ground water yield of 1,500 acre-feet per year. Because of the expected magnitude of growth, an extensive surface water supply development should be competitive with ground water prices and this source will be preferred to ground water because of limited ground water yield as contrasted with water needs. Therefore, the demand for a surface water supply is expected to be equal to the gross figures in Table 1.

3. Supplemental water will have to be supplied from surface water sources in the basin, or will have to be imported from nearby hydrological basins.

4. The feasible alternative sources of the additional water supply appear

TABLE 1

PROJECTED WATER USE IN ACRE-FEET PER YEAR
SOQUEL-APTOS AREA

Study Area	1960	1980	2000	2020	2040	2060
Santa Cruz-Soquel	745	1,110	1,750	2,110	2,445	2,820
Soquel	630	2,235	3,535	4,295	5,110	5,925
Aptos	95	720	1,690	2,315	2,660	3,055
La Selva	50	710	1,195	1,455	1,740	1,920
Total Water Use	1,520	4,775	8,170	10,175	11,955	13,720

to be: (a) single-purpose reservoirs on Aptos and/or Soquel Creek; (b) single-purpose reservoir in Doyle Gulch, using water diverted from Soquel Creek; (c) importing water from the Santa Cruz System; and (d) importing water from South Bay Aqueduct or San Luis Projects.

5. Information on yields and cost estimates of all alternatives listed above were not available to the USPHS at the time this report was prepared. However, a cost estimate for a single-purpose water supply reservoir on Soquel Creek, based on information from the State of California, indicates a value of approximately $32.50 per acre-foot of yield.

6. The quantities of water developed from surface supplied will require more extensive treatment than the treatment presently given to the ground water used in the Soquel-Aptos Basins.

7. The possible conflicts between land use and water quality should be considered. Extensive recreational use of water supply reservoirs and urban developments surrounding a reservoir (such as the Glenwood Development) may create a public health problem.

8. The need for storage for regulation of flow for quality control has not been determined. However, both Soquel and Aptos Creeks are less than six miles long and have steep gradients to the ocean. There is no existing discharge of municipal or industrial wastes to these streams and none is anticipated in the future. The communities of Santa Cruz, Capitola and Soquel currently discharge their wastes to the ocean. From this cursory examination, it appears that additional flow in Soquel and Aptos Creeks for quality control will not be necessary.

III. GENERAL DESCRIPTION OF THE AREA

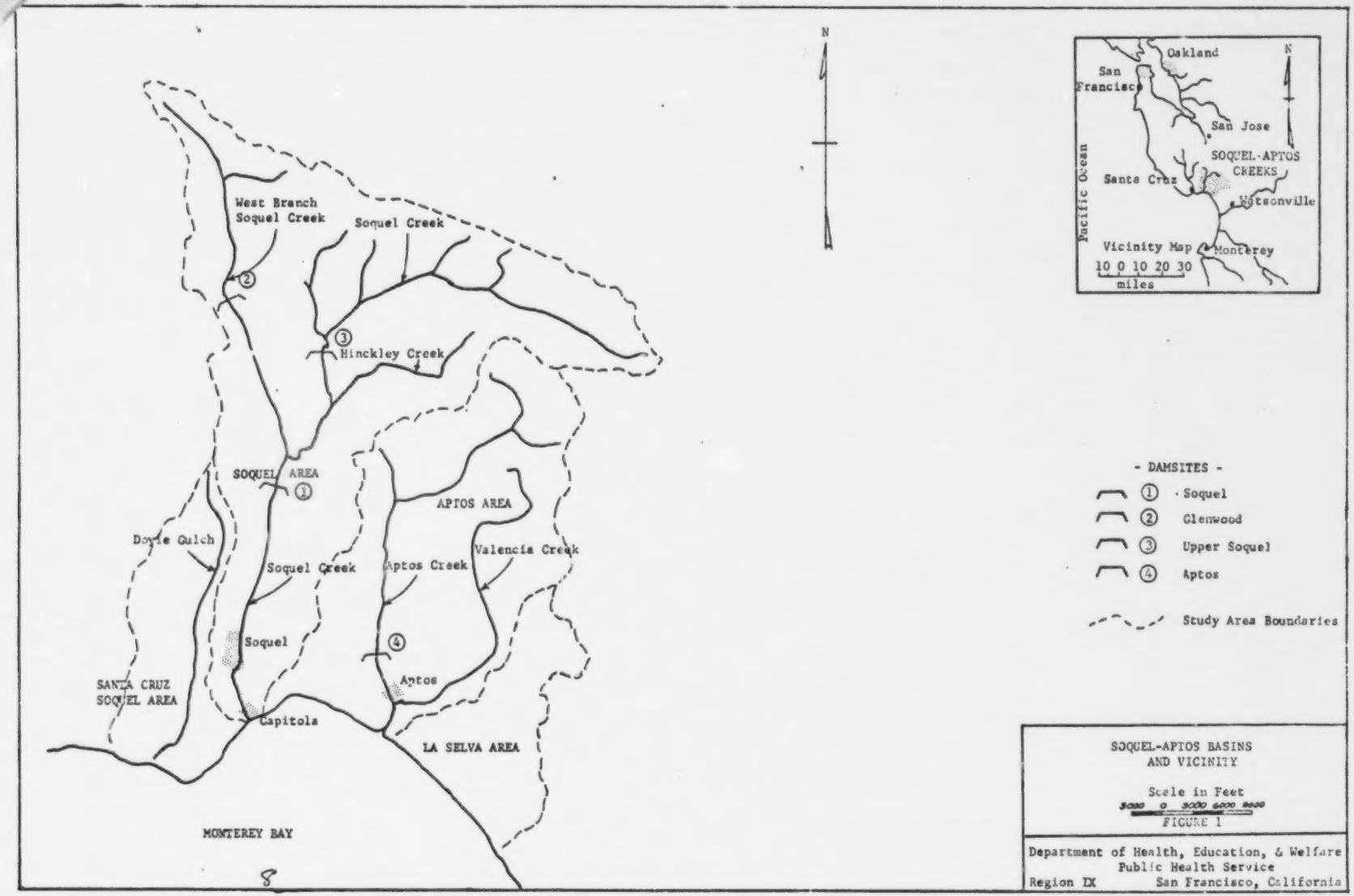
The Soquel-Aptos Basins are located about 70 miles south of San Francisco, immediately east and south of the town of Santa Cruz. The basins lie entirely within Santa Cruz County.

A. Physical Aspects of the Area

The land is not extensive (67,000 acres) but a variety of land types are located in the area. The area borders on the Pacific Ocean and includes approximately ten miles of shoreline. The shoreline beaches are a desirable recreational area. North of the beaches are the uplands, rising from the shore to the 200 foot elevation in a zone varying in width from 1/2 mile to 3 miles. From the 200 foot elevation, the land, which rises to a 3,000 foot elevation, forms moderate mountains and valleys within which the streams originate. The principal streams are Soquel and Aptos Creeks and their tributaries, and two minor basins, Doyle Gulch and Arana Gulch (about 5,000 acres in area), lie west of Soquel in the Soquel-Santa Cruz Area.

The Basins have been divided into four study areas by the Corps of Engineers, as shown in Figure 1. The principal watershed is in the Soquel Area, with a mean annual runoff of 31,400 acre-feet in Soquel Creek at Soquel, California. The other important watershed is the Aptos Area, with Aptos Creek having a mean annual runoff of 7,400 acre-feet at Aptos, California. The remaining areas, Santa Cruz-Soquel and La Selva, are smaller watersheds and drain directly to the sea. The proposed Corps of Engineers developments are located in the Soquel and Aptos Areas and are illustrated in Figure 1.

The amount of rainfall varies from about 25 inches per year to 45 inches per year in the basin. The amount of rainfall appears to be a function of


N
West Branch
Soquel Creek
Soquel Creek
Hinckley Creek
SOQUEL AREA
APTOS AREA
Doyle Gulch
Soquel Creek
Aptos Creek
Valencia Creek
Soquel
Aptos
SANTA CRUZ
SOQUEL AREA
Capitola
LA SELVA AREA
MONTEREY BAY
Oakland
San
Francisco
San Jose
SOQUEL-APTOS
CREEKS
Santa Cruz
Watsonville
Pacific Ocean
Vicinity Map
Monterey
10 0 10 20 30
miles
- DAMSITES -
1 Soquel
2 Glenwood
3 Upper Soquel
4 Aptos
Study Area Boundaries
SOQUEL-APTOS BASINS
AND VICINITY
Scale in Feet
5000 0 3000 6000 9000
FIGURE 1
Department of Health, Education, & Welfare
Public Health Service
Region IX San Francisco, California

elevation, a consequence of the orographic lifting of clouds over the mountains. Because of this pattern of rainfall, and the topographic characteristics, several of the "mountain" dam sites would appear to create favorable flood control and water conservation sites but construction cost have not been considered.

B. Economic and Social Factors

Subdivisions, shopping centers and schools are being constructed in the more accessible parts of the basins. The parts so affected are changing in character from rural to "suburban" type areas. The older, established communities, many of which have deteriorated during the last 25 years, are undergoing rehabilitation slowly. It is anticipated that this urban renewal activity will be accelerated considerably during the next ten to fifteen years. The local economy, which is based almost entirely on agriculture and tourism, is undergoing significant changes; for example, light manufacturing, including the production of electronic components, has been introduced into the area and the service industries are expanding. The availability of a growing labor force, which includes a high proportion of women, together with the probable establishment of a large branch of the University of California, should stimulate the further expansion of light precision manufacturing. The projected development of recreational facilities, together with the natural scenic attractions of the area, should promote tourism to an even more important place than it now occupies in the economy. Agriculture is expected to decline as residential communities and recreational facilities expand into lands presently used for farming.

IV. HYDROLOGY AND WATER QUALITY - DETERMINANTS OF WATER AVAILABILITY

The feasible sources of water appear to be surface water or ground water. Descriptions of these resources in the basin follow.

A. Hydrology of Surface Waters

The watersheds of the area are characterized by steep topography with a short run to the sea. Rainfall, which is heaviest in the upper portion of the basins, averages about 30 inches per year at the 500 foot elevation and increases to 45-50 inches per year at elevations above 1,500 feet. The stream flows at four potential dam sites are shown in Table 2.

TABLE 2

MEAN ANNUAL, MINIMUM AND MAXIMUM FLOWS FOR FOUR DAM SITES [a/]

Dam Site	Stream	Mean Annual (ac-ft)	Minimum Annual (ac-ft)	Maximum Annual (ac-ft)	Years of Record
Lower Soquel I_A	Soquel Creek	27,600	3,600	70,500	1901-1960
Glenwood	West Branch Soquel Creek	7,000	900	17,900	1901-1960
Upper Soquel	Soquel Creek	9,200	1,400	27,800	1901-1960
Aptos	Aptos Creek	7,400	800	16,800	1930-1961

[a/] Source: U. S. Corps of Engineers preliminary estimates, subject to revision.

B. Surface Water Quality

The only available data on water quality for the Soquel and Aptos Creeks is that collected by the California State Department of Water Resources for

their surface water quality monitoring program. As part of this program, one sampling station was established on Soquel Creek at river mile 1.4 (the same location as the USGS streamflow gage). The sampling station was established in 1951, and since that time monthly samples have been collected and analyzed by the Department. Table 3 shows the ranges of some of the more important water quality parameters.

Based on the information above, it can be concluded that the Soquel Creek water is only fair, from a drinking water quality viewpoint, for a municipal and/or industrial water supply source. The high hardness concentrations, which probably are due to the natural geology of the area, would cause trouble with some industrial operations and would cause a certain amount of consumer dissatisfaction. In addition, the presence of dwellings within the watershed area and above the proposed reservoir sites creates a potential hazard to the public health. The quality of water in the reservoir would tend to average near the minimums of the reported qualities. The winter runoff, which will fill the reservoir, is usually the better quality water, as better quality tends to be correlated with higher flows.

It is not likely that surface water quality will improve in the future. More intense residential settlement and an increased recreational use of the basin will probably have a detrimental effect on natural quality. In addition, the chemical quality of any water stored in the proposed reservoirs would probably deteriorate to some degree from natural causes. Appendix B outlines some potential problems resulting from natural physical, chemical and biological factors. Unlike ground water which usually requires only chlorination, surface water would have to receive at least minimum treatment of coagulation, filtration and chlorination. It is probable, too, that the water would have to be softened for consumer convenience.

TABLE 3

WATER QUALITY DATA - SOQUEL CREEK AT SOQUEL [a]

Year	Chlorides mg/l		Total Hardness As $CaCO_3$ mg/l		Temperature °F		pH		Coliform [b] MPN/ml		Total Dissolved Solids mg/l	
	Max.	Min.	Max	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
1955	102	12	324	184	65	45	8.2	7.1	2400.	2.3	580	175
1956	73	13	318	165	66	47	7.9	7.1	7000.	2.3	500	260
1957	81	16	310	141	74	45	8.4	7.9	7000.	5	530	235
1958	74	15	298	164	78	48	8.3	7.6	620.	2.3	490	260
1959	92	25	309	215	68	45	8.1	7.5	2400.	1.3	511	350
1960	86	30	330	159	79	48	8.1	7.5	7000.	6.2	560	250
1961	106	51	370	276	78	50	8.4	7.7	500.	0.62	640	450
1962 [c]	98	24	354	237	75	51	8.6	6.8	7000.	0.62	600	370

[a] Data obtained from California State Department of Water Resources

[b] TDS computed from specific conductance measurements

[c] Records for period January - August

C. Hydrology and Quality of Ground Waters

1. Quantity

The principal source of ground water in the Soquel-Aptos Basins is Soquel Valley. A description of this aquifer is found in a State of California Report, as follows:

> "The Soquel ground water basin consists of a forebay zone, a pressure zone, and a body of free ground water above the confined aquifer in the pressure zone. The pressure zone, which comprises the floor of Soquel Valley, has an areal extent of approximately 5 square miles and the ground water is confined by a thin stratum of well-cemented 'hard shell' fossiliferous sandstone." 2/

> "The pressure aquifer is the stratum of Purissima sand mentioned above, and a layer or layers of the 'hard shell rock' form the confining bed." 3/

> "Indications are that this aquifer is not over 60 feet in thickness, although other water-bearing strata could occur within the Purissima at greater depths, beyond the limits of present drilling efforts." 4/

The State estimated that the yield from ground water could exceed the estimated 1952 pumping rate of 600 acre-feet. Brown & Caldwell, Consulting Engineers, report:

> "Data reviewed for this preliminary report do not provide an adequate basis for any firm conclusions regarding the quantity of water which may be developed from underground sources. It appears that at least 1,500 acre-feet per year can be taken from the ground water reservoir without creating any problems of sea water intrusion. No estimate has been made of the maximum possible ground water draft." 5/

It appears that the ground water supply will sustain the present pumpage rate (about 1,300 acre-feet) and will allow for a limited amount of additional pumpage (perhaps 200 acre-feet). A detailed investigation would be required to accurately establish the amount of additional pumpage allowable.

2. Quality

The quality of the Soquel Valley ground waters has been described by the State as containing "substantial amounts of iron and manganese which render the water undesirable for general domestic and some industrial uses." 6/

"The mineral concentrations are attributed to the presence of Purisima sand, containing ilmenite and magnetite, in the aquifer." 7/

"Development of the ground water in the Soquel Creek Basin should include provisions for the construction of treatment facilities designed to reduce the iron and manganese content of the water." 8/

Present treatment of water by the Monterey Bay Water Company, serving parts of the Soquel and Aptos Area, is chemical dosage with phosphate compounds and hypochlorite. 9/ Data on the chemical analyses of this raw ground water are presented in Table 4.

TABLE 4

GROUND WATER QUALITY, APTOS - SOQUEL AREA a/

Source	Well Depth	Chemical Analysis - mg/l					
		TDS	Hardness	Chlorides	Iron	Nitrates	Fluorides
Monterey Bay Water Company Two Wells Serving Aptos	285' & 400'	351	219 to 227	193 to 197	<0.1	<1	0.1 to 0.2
Monterey Bay Water Company Four Wells Serving Capitola	207' to 250'	251 to 633	128 to 318	27 to 62	<0.1 to 1.8	<1 to 2	0.1 to 0.3

a/ Source: State of California, Department of Public Health, California Domestic Water Supply Statistics - 1958.

D. Existing Sources of Water

At the present time the water supply for the study area is mostly derived from ground water in Soquel Valley and the Coastal Plan. Both the Beltz Water Company and the Monterey Bay Water Company which serve Aptos, Capitola and Soquel, depend on wells for water supply. Individual consumers not connected to any developed water system obtain water from either private wells, springs or makeshift diversions from existing creeks.

The City of Santa Cruz has developed some surface water storage in the San Lorenzo River Basin and is investigating possible means for enlarging its system. Presently under consideration are the Doyle Gulch Reservoir and other alternatives in the San Lorenzo Basin. It has also been reported[10/] that Santa Cruz has filed for a water right permit of 16,000 acre-feet per year from Soquel Creek.

If the City enlarges the system, it may also extend its service area to include Capitola, Soquel, Aptos and La Selva. Such a unified water district would furnish a higher level of service to the consumer.

V. POPULATION, ECONOMICS AND LAND USE - DETERMINANTS OF WATER USE

Water use appears to be a function of many factors, e.g., population, land use, climate, quality of water, industrial composition, and availability of water. The cumulative effect of the variables other than population, land use and economics acts to cause the water use patterns of different areas to vary more widely than would be expected from changes in the three variables alone. Therefore, to anticipate and project changes for an area, given projected changes in population, economics and land use, requires an historical review and a comparison of the study area with similar areas.

A. Existing Water Use

At present, water use in the "lower" part of the study area that is served by the three water companies is estimated at 1,300 acre-feet for 14,000 - 15,000 people, an average of 78 - 83 gpcd. [11/] This use figure appears to be low compared with the reported use in Santa Cruz, but is comparable to reported use in Watsonville. These figures are shown in Table 5.

The water use in the area is primarily residential, with only a few industrial operations in the vicinity of Santa Cruz. In addition, the population of the study area has a higher than average proportion of older persons. The area has been growing, approximately 2 percent per year, and many older homes and small houses are found. The extensive suburbs are not common. The combination of low industrial development, older and more densely spaced homes, and the living habits of older persons and lower income groups contribute to the present water use which appears low in comparison with other regions in California.

Other reasons for "low" water use may be the water quality and the

TABLE 5

REPORTED WATER USE IN THE MONTEREY BAY AREA [a]

County	Community	Estimated Population Served	Average Water Use (MGD)	Average Water Use (gpcd)
Santa Cruz	Aptos	2,500	0.160	64
	Monterey Bay Water Co. Capitola-Soquel System	6,000	0.400	67
	Santa Cruz	33,000	5.3	160
	Watsonville	21,732	1.75	81
Monterey	Castroville	2,100	0.100	48
	California Water & Telephone Co., Monterey Peninsula Division	80,622	7.270	90
	Seaside	8,800 [b]	3.0	341

[a] Source: USDHEW, PHS "Municipal Water Facilities, Inventory as of January 1, 1958", PHS Publication No. 775, Vol. 9, 1960.

[b] The 1960 Census reported a population of 19,353 people for Seaside.

distribution system. The portion of the study area that is served by the three water companies is dependent on ground water from wells. A report by Brown & Caldwell, Consulting Engineers, to the Santa Cruz Water Company, dated February 14, 1962, stated:

> "From the standpoint of chemical quality, most of the wells would be considered marginal. About one-half of the wells produce water containing excessive amounts of iron and manganese. In some cases the discoloration resulting from the presence of these minerals is controlled by means of treatment with a polyphosphate. Hardness of the water varies from about 100 mg/l (milligrams per liter) to 300 mg/l.
>
> "In general, the distribution systems consist of 6 and 8-inch supply mains, connecting wells and storage tanks. Practically all distribution

mains are 4 inches and smaller in diameter. In several areas the distribution mains lack sufficient capacity to maintain adequate pressures during periods of peak demand."

B. Future Water Use

If a better quality of water is available in adequate quantity, then it might be postulated that per capita water use will increase (assuming little or no change in water price). The extent that water use might increase could be inferred from some estimates for Santa Cruz, where the water use averages 160 gpcd, with adequate quantity and quality. Brown & Caldwell, Consulting Engineers, have studied the water use patterns in Santa Cruz and have established some use figures based on residential densities. The per capita water use varies inversely with density, about a 2-fold range. This 2-fold range in per capita residential use as a function of density was incorporated in the projections.

Water use projections have been calculated as a function of population, economic character and land use. The Corps has furnished projections for use in this report. These are shown in Table 6, Population Projections; Table 7, Employment Projections; Table 8, Recreation Use Projections; and Table 9, Land Use Projections. These projections are for the period 1960 - 2060.

The water use projection tool is a matrix-vector procedure, recognizing five categories of use: industrial employment, service employment, visitors-service, visitors-sanitary and residents. The details of the projecting method are presented in Appendix A. Taking the vector of user numbers given by the Corps' projections, and solving for some values of unit use, given the present water use of around 1,300 acre-feet per year for 14,000 people, resulted in the matrix of unit uses shown on the following page.

1960 UNIT WATER USE MATRIX

Use	Industrial	Service	Visitors Service	Visitors Sanitary	Residents
Gallons per capita per day	100	20	10	10	50-90 a/

a/ Residential use per capita is a function of residential density.

The water use numbers that resulted from the solution of the matrix equation seem "in line" with presently observed use figures, averaging 84 gpcd for the projected 1960 water use of 1,520 acre-feet for 16,200 people.

In the future, water use per capita is expected to increase as better water service becomes available. This forecast is shown in Table 10 where it can be seen that a 50 percent increase in the residential unit water use figure is expected by the year 2000. This trend will be caused by the better water service that will be available as well as the expected demographic and economic changes. At present there is a definite sector of the population with a low income (e.g., retired persons) and also some "seasonal" or summer homes. As the area develops, competition for land will probably change the type of uses, with higher incomes and a more "permanent" working population, as well as the changing character of residential structure will result in an increase in per capita residential water use.

TABLE 6

POPULATION PROJECTIONS SOQUEL-APTOS BASINS [a]
1960-2060

Year	Total Service Area	Area			
		Santa Cruz-Soquel	Soquel	Aptos	La Selva
1960	16,200	9,800	5,000	900	500
1980	40,000	13,000	14,500	5,500	7,000
2000	60,500	17,500	21,000	12,000	10,000
2020	73,500	20,500	25,000	16,000	12,000
2040	84,000	23,000	29,000	18,000	14,000
2060	93,500	25,500	33,000	20,000	15,000

[a] Source: Corps of Engineers

TABLE 7

EMPLOYMENT PROJECTIONS, TOTAL SERVICE AREA [a]
1960-2060

Year	Total Employment	Employment Category		
		Agriculture	Industry	Service [b]
1960	5,860	590	1,210	4,060
1980	12,800	470	3,530	8,800
2000	19,300	390	4,780	14,130
2020	23,500	130	5,740	17,630
2040	27,700	40	6,720	20,940
2060	31,000	< 10	7,600	23,400

[a] Source: Corps of Engineers

[b] Service is called "Others" in the Corps' terminology. We define service to include both services and trades.

TABLE 8

RECREATION USE PROJECTIONS, SOQUEL-APTOS BASINS [a]
1960-2060

Year	Total Visitor Days	Day Use	Overnight Use (Camping)
1960	1,500,000	1,200,000	300,000
1980	3,150,000	2,520,000	630,000
2000	7,900,000	6,120,000	1,580,000
2020	13,490,000	10,492,000	2,698,000
2040	20,150,000	16,120,000	4,030,000
2060	28,500,000	22,800,000	5,700,000

[a] Source: Corps of Engineers

TABLE 9

LAND USE PROJECTIONS, SOQUEL-APTOS BASINS [a]
(Land Area - Acres)
1960-2060

Year	Residential & Commercial	Industrial	Agriculture	Public & Reserved [b]	Unused & Undeveloped
1960	4,030	180	8,340	1,050	39,400
1980	13,900	340	5,300	11,200	22,260
2000	20,200	500	4,000	11,400	16,900
2020	24,500	620	1,000	11,900	14,980
2040	26,800	770	330	13,800	11,300
2060	29,100	800	110	13,900	9,090

[a] Source: Corps of Engineers

[b] The large change in Public & Reserved Acreage is due to the proposed acquisition of a 10,000 acre park-site near Aptos.

TABLE 10

WATER USE PROJECTIONS, SOQUEL-APTOS BASINS
Quantity of Water Use - Acre-Feet per Year

	1960	1980	2000	2020	2040	2060
SANTA CRUZ - SOQUEL						
Industrial	85	110	170	200	235	270
Service	60	85	110	140	160	180
Visitor-Service	30	35	80	130	190	280
Visitor-Sanitary	20	5	20	30	60	90
Resident	550	875	1,370	1,610	1,800	2,000
Total	745	1,110	1,750	2,110	2,445	2,820
SOQUEL						
Industrial	50	145	200	250	280	315
Service	25	85	120	140	170	190
Visitor-Service	10	35	85	135	210	290
Visitor-Sanitary	5	30	70	130	230	320
Resident	540	1,940	3,060	3,640	4,230	4,810
Total	630	2,235	3,535	4,235	5,110	5,925
APTOS						
Industrial	5	135	160	180	210	235
Service	5	10	40	70	70	80
Visitor-Service	5	5	30	65	90	120
Visitor-Sanitary	10	50	120	210	270	380
Resident	70	520	1,340	1,790	2,020	2,240
Total	95	720	1,690	2,315	2,660	3,055
LA SELVA						
Industrial	-	5	10	15	25	35
Service	5	20	35	45	60	75
Visitor-Service	-	10	25	45	75	110
Visitor-Sanitary	5	5	5	10	10	20
Resident	40	670	1,120	1,340	1,570	1,680
Total	50	710	1,195	1,455	1,740	1,920
Grand Total	1,520	4,775	8,170	10,175	11,955	13,720
Per Capita (gpd)	84	107	121	124	127	131

VI. NEEDS, ALTERNATIVES AND VALUES

A. Needs

The definition of the word needs when applied to a basic commodity such as water is rather nebulous. A certain quantity of water is required or needed to sustain life. An additional amount of water is necessary (but not needed) to maintain personal comfort. An even larger quantity of water is presently used to support our standard of living. In making future projection of gross water use in the Soquel-Aptos Study Area, no attempt was made to distinguish between basic needs, personal requirements and amounts desired to maintain a certain standard of living.

The water use projections shown in Table 1 are forecasted from existing base use in the study area. The basic assumption used in making these projections was that quantity would not be a constraint on future use. Consequently, it was projected that per-capita consumption would increase in most sub-areas of the basins and future water needs would increase accordingly.

Based on the Corps of Engineers' economic projections for the study area, it is calculated that the existing supplies will no longer be adequate after 1970. The existing water supply is derived mostly from a limited ground water basin in the Soquel Valley. It is estimated that the safe yield from this ground water basin is approximately 1,500 acre-feet per year, and combining this with other minor sources, there should be a "sufficient" amount of water to supply all beneficial uses until sometime near 1970. After this date, additional supplies will be needed to furnish adequate water supply service for the anticipated growth.

B. Alternatives

A need for the development of additional water supplies for future use does exist, and there are several alternative sources for obtaining this supply. However, it appears that the most feasible alternatives involve some type of development of surface waters within the Soquel Basin. Several alternative sources of supply are enumerated below:

1. Water could be obtained from the South Bay Aqueduct (part of the California Water Plan Facilities) by pumping it over the hill or through a tunnel, or exchanging it with the Santa Clara County Flood Control and Water Conservation District or the San Jose Water Works for water stored in their reservoirs near Los Gatos; or by diverting from the southern terminus of the aqueduct in to the Pajaro River and pumping up the coast. It is estimated that this source would be relatively expensive and more or less a last resort.

2. Water might be obtained from the San Luis Project Reservoir near Los Banos, California (in the Central Valley of California) and pumped into the Pajaro River and further downstream it could be diverted or pumped to the Soquel-Aptos Area. This alternative, as well as the others, would involve consideration of both quantity and quality.

3. Sea water conversion could serve as a method for obtaining a new fresh water source. The state of technology and the economics of the process are changing with time because of research in the field. It does not appear now that this source would be economically competitive. Existing conversion plants can produce fresh water for about $1.00 per 1,000 gallons ($325 per acre-foot), not including the cost of distribution. Most domestic supplies cost the consumer between $20 and $70 per acre-foot for raw water and treatment, but not including distribution costs. Delivery costs may add $70 to $150 per acre-foot.

4. Based on yield estimates supplied by the Corps of Engineers, it appears

that multiple purpose development of the Soquel Creek watershed could provide a sufficient quantity of water to satisfy the Study Area needs for the duration of the study period. This development could either involve facilities on Soquel Creek or facilities on Soquel Creek and Doyle Gulch.

The most feasible alternative appears to be either a single dam on Soquel Creek or a combination project on both Soquel Creek and Doyle Gulch. The Doyle Gulch facility would provide additional storage capacity resulting in a smaller development on Soquel Creek.

C. Values

There are several alternative means by which municipal and industrial water supply could be obtained for the Soquel-Aptos Area.

The presently accepted approach for determining value is by use of the least cost alternative doctrine. In essence, this method assumes that the minimum value of the resource is indicated by the price of the least costly alternative. The philosophy behind the least cost alternative doctrine is that the cost of a single-purpose alternative project represents the lower limit of the amount of resources that the potential consumer would be willing to trade.

From a water supply standpoint, there are two dimensions of value; i.e., value of quantity and value of quality. Consequently, for the projects under consideration, value must be determined (using the least cost alternative approach) on the basis of the minimum cost for supplying a quantity of water at a comparable quality. Some additional concepts of value are given in Appendix C at the end of this report.

A cursory examination of the possible alternatives leads to the conclusion that a single-purpose project on Soquel Creek would be the least costly alternative. Based on estimates prepared by the California State Department of

Water Resources, [1] the cost per acre-foot of water can be computed as shown below:

Reservoir Capacity, Acre-Foot		38,600
Safe Seasonal Yield, Acre-Foot		18,300
1952 Construction Cost		$9,794,000
1963 Construction Cost estimated on basis of ENR Index	$9,794,000 x $\frac{960}{600}$ =	$15,670,000
Average Annual Cost based on 50 year life and 2-7/8% interest	$15,670,000 x 0.037945 =	$595,000
Average Annual Cost per acre-foot of yield		$32.51

D. Summary

The Soquel-Aptos Area will need additional municipal and industrial water supplies in the near future. Several multi-purpose projects have been proposed to satisfy this need. The value of these projects can be imputed on the basis of the least cost alternative project for supplying adequate quantities of water of comparable quality. Table 11 summarizes the alternative projects. The comparison cost of each alternative would be the total cost of each alternative source to deliver water of comparable quality to a point in the service area, say the treatment plant, less the cost of transmission of the multiple-purpose projects' water to this point. This net figure of alternative cost provides a valid comparison of all alternatives with the cost of multiple-purpose project water at the impoundment.

TABLE 11

SUMMARY OF ALTERNATIVE WATER SOURCES

Alternative	Facilities Needed[a/]	Remarks	Average Annual Cost Should Include:
1. Importation from outside Basin			
a. South Bay Aqueduct	Transmission facilities from near San Jose and storage near service area.	Quality is unknown.	Cost of water, physical facilities, operation and maintenance.
b. San Luis Project	Transmission facilities from near Watsonville and storage near service area.	"	"
c. Purchase water from San Jose Water Works (possibly exchanging water from South Bay Aqueduct.	Transmission facilities from reservoirs west of Los Gatos area.	Quality considerations may be less significant	Cost of replacement water, physical facilities, operation and maintenance.
2. Single-purpose water supply projects on Soquel Creek.	Reservoir and transmission to service area.	Adequate quality and quantity.	Cost of construction of impoundment and transmission, operation and maintenance.
3. Combination single-purpose project on Soquel Creek and Doyle Gulch.	Reservoirs on both streams. Transmission facilities to service area.	Smaller reservoirs needed.	Cost of construction of impoundments and transmission and O&M.
4. Purchase water from City of Santa Cruz.	None	Comparable quality; consistent high level service; Santa Cruz would develop local streams for water supply.	Cost of water.

[a/] All sources except number 4 would require treatment.

APPENDIX A

WATER USE PROJECTION METHODOLOGY

The projection technique involves calculating the product of a matrix and a vector. The matrix represents the categories of water use, the vector represents inputs, e.g., population. All use figures are expressed in gallons per day and are then converted to acre-feet per year.

A sample calculation is the following for the 1960 use in the Santa Cruz - Soquel Area:

	(Water Use per Industrial Employee (100 gpd)		
	(		
	(x Number of Industrial Employees (740)	=	74,000)
+	(Water Use per Service Employee (20 gpd)		
	(		
	(x Number of Service Employees (2,740)	=	54,800)
+	(Water Use per Visitor for Service (10 gpd)		
	(		
	(x Number of Visitors for Service (2,400 per day)	=	24,000)
+	(Water Use per Visitor - Sanitary Use (10 gpd)		
	(		
	(x Number of Visitors - Sanitary Use (2,040 per day)	=	20,400)
+	(Water Use for Residents (50 gpd)		
	(		
	(x Number of Residents (9,800)	=	490,000)
	Water Use per Year (663,000) (0.00112)	=	745 acre-feet

The input vectors used are shown in Table 12. The unit water use matrix values are shown in Table 13.

The Corps of Engineers furnished the numbers for the input vectors and these were used following the definitions below:

A. Industrial Employment. Corps' industrial employment forecast for the total basin is summarized in Table 8; the figures by sub-basin are shown in Table 12.

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TABLE 12

INPUT VECTORS FOR WATER USE PROJECTIONS, SOQUEL-APTOS BASINS
Water Using Populations

	1960	1980	2000	2020	2040	2060
SANTA CRUZ - SOQUEL						
Industrial	740	1,000	1,500	1,800	2,100	2,400
Service	2,740	3,800	5,100	6,210	7,170	8,100
Visitor-Service	2,400	3,180	6,900	11,700	17,200	25,400
Visitor-Sanitary	2,040	520	1,500	2,700	5,600	8,000
Residential	9,800	13,000	17,500	20,500	23,000	25,500
SOQUEL						
Industrial	450	1,300	1,800	2,200	2,500	2,800
Service	1,130	3,860	5,540	6,370	7,690	8,400
Visitor-Service	1,000	3,250	7,500	12,000	18,800	26,100
Visitor-Sanitary	210	2,510	6,300	11,700	20,300	29,000
Residential	5,000	14,500	21,000	25,000	29,000	33,000
APTOS						
Industrial	20	1,200	1,400	1,600	1,900	2,100
Service	170	280	1,980	2,990	3,300	3,600
Visitor-Service	140	220	2,700	5,700	8,100	10,900
Visitor-Sanitary	930	4,220	11,000	18,300	23,800	34,000
Residential	900	5,500	12,000	16,000	18,000	20,000
LA SELVA						
Industrial	-	30	80	140	220	300
Service	20	860	1,510	2,060	2,780	3,300
Visitor-Service	40	750	2,100	4,000	6,600	10,100
Visitor-Sanitary	400	150	400	700	1,000	1,500
Residential	500	7,000	10,000	12,000	14,000	15,000

TABLE 13

UNIT WATER USE MATRICES, SOQUEL-APTOS BASINS
Water Use - Gallons per Capita per Day

	Basic Matrix				
	Industrial	Service	Visitor-Service	Visitor-Sanitary	Residents
Process and Service	80	0	10	0	10
Domestic and Sanitary	20	20	0	10	Varies between 40 and 120 depending on time and area.[a/]

[a/] Residential Domestic and Sanitary Water Use

Area	1960	1980	2000	2020	2040	2060
Santa Cruz - Soquel	40	50	60	60	60	60
Soquel	80	100	120	120	120	120
Aptos	60	75	90	90	90	90
La Selva	60	75	90	90	90	90

B. Service Employment. Corps' other employment forecast by sub-basin.

C. Visitors. Corps' forecast on visitors from outside the basin.

D. Residents. Corps' forecast for population.

E. Visitors-Service. Distributed in proportion to service population.

F. Visitors-Sanitary. Distributed in proportion to acreage of public and reserved land area.

Water Use Matrix Formulation. The origin of the numbers.

A. Industrial Use. Is estimated at 100 gallons per day per employee, based on the national water use figures shown in Table 14. No trend factor is assumed.

B. Service Use. Is estimated at 20 gallons per day per employee, based on use for toilets and washing.

C. Visitors-Service. Is estimated at 10 gallons per day, representing water used in preparing food, dishwashing and laundry, plus possible motel use which may be up to 50 gallons per visitor day.

D. Visitor-Sanitary. Is estimated at 10 gallons per day, including toilet use. The California Division of Beaches and Parks estimates the following water uses:

Type of User	Quantity of Use (gallons/visitor day)
Day Use	5
Overnight (with showers)	35
Overnight (no showers)	25

There is no charge for use of showers in state parks at present although there is an entrance fee.

About 1/5 of the visitors to the area will use the camping facilities and several thousand motel units will be available. If half of the

TABLE 14

LIGHT INDUSTRIAL WATER USE [a]

Industrial Code	Industry	National Average Water Use (Gal/Employee-Day)	
		Total	Process
3429	Hardware	442	252
3452	Bolts, Nuts, Washers & Rivets	407	204
354	Metalworking Machines	281	56
356	General Industrial Machines	264	100
357	Office Machines	393	71
358	Service Industrial Machines	282	71
3611	Electric Measuring Instruments	159	159
3621	Motors and Generators	345	86
363	Household Appliances	527	208
3651	Radios and TV Receiving Sets	196	98
3661	Telephone, Telegraph Apparatus	644	86
3662	Radio, TV Communication Goods	508	46
3671	Electric Tubes, Receiving Type	108	-
3672	Cathode Ray Picture Tubes	628	-
3673	Electric Tubes, Transistor	537	268
3679	Electric Components	284	57
369	Electric Products	331	197
3722	Aircraft Engines and Parts	1775	420
3811	Scientific Instruments	148	-
3821	Mechanical Measuring Devices	129	-
3822	Automatic Temperature Control	408	135
384	Medical Equipment and Supplies	300	300
3861	Photographic Equipment	760	483

[a] Source: U. S. Bureau of Census, U. S. Census of Manufacturers: 1958 Industrial Water Use, Subject Report MC58(1)-11, U. S. Government Printing Office, Washington, D. C., 1961.

expected visitors were for day use at 5 gpd, 1/4 ate meals and used sanitary facilities at 20 gpd, and 1/4 required motels or overnight camping at 40 gpd, it would result in an average water use of (.5(5) + .25(20)+ .25(40)) = 17.5 gallons per day. The projected figures are in visitor days rather than activity days, so our estimates do not "double-count" water users.

The distinction between service water and sanitary water is not significant for water use projections (important for projecting pollution loads, though) so we arbitrarily divided total water use per visitor day (20 gallons) between the two categories of use at 10 gallons each.

E. Residential Use. Is estimated as a function of density, based on the study of Santa Cruz by Brown & Caldwell, Consulting Engineers. The two-fold increase in unit water use as land-use density decreases was incorporated into an equation to calculate residential water use, assuming representative values for the other components of water use. The relative ratios of water use by area was assumed to be 1, 1.5, 2 as follows: one (1) for the Santa Cruz Area; one and one half (1.5) for the Aptos and Selva Areas; and two (2) for the Soquel Area. The base water use that resulted from calculations was 40 gpcd. This base was then multiplied by the ratio factor, giving three use figures - 40, 60 and 80 gpcd, as shown in Table 13.

In addition to this residential-sanitary use, a quantity of 10 gpcd was added to represent service water required for residents for their restaurant use, laundering service, etc.

APPENDIX B

EFFECTS OF STORAGE IMPOUNDMENTS ON WATER QUALITY

The quality of water stored in an artificial impoundment may vary greatly from the quality of the inflow. The quality variations can be either beneficial or determinetal to the water user. Beneficial effects, such as a reduction in turbidity and dilution of inflow to give a fairly constant quality, facilitate water treatment operations. Detrimental quality changes which may occur are: (1) increased growth of plankton; (2) temperature stratification of the reservoir resulting in a zone of near septicity in the lower depths; and (3) increases in the dissolved mineral concentration.

If the impoundment is to be used as a source for domestic and industrial water supply, the detrimental quality changes can lower the economic value of the supply. One type of algae, the blue-green, has been implicated as a major cause of taste and odor problems. Other plankton forms (both algae and diatoms) cause difficulty in water treatment plants by clogging the filters. Thermal stratification becomes a problem because of the resistance of a thermally stratified reservoir to mixing. The more dense hypolimnion serves as a repository for all of the settleable organic and inorganic material. The decaying organic material depletes the oxygen resources and may cause tastes, odors and unsightly discoloration. In addition, if the reservoir is subject to seasonal overturns, the result may be a prolific plankton bloom stimulated by the large quantities of nutrient material in the lower depths. Problems of thermal stratification can often be minimized or overcome through the provision of reservoir outlets at several depths.

The third detrimental effect, the increase in dissolved minerals and hardness, depends on the bacterial activity, chemical characteristics of the

water, and the geo-chemistry of the inundated land. For example, the East Bay Municipal Utility District has reported [12/] that water from Pardee Reservoir, with an average hardness of about 20 mg/l, increases from 4 to 10 times this hardness concentration after storage in local distributing reservoirs.

Water quality can be a definite constraint on the usefulness of water stored in an impoundment. A poor quality water requiring a high degree of treatment is expensive for the consumer. Consequently, the water quality aspects should be considered during the planning stage of any reservoir intended to serve as a source for municipal and/or industrial water supply.

APPENDIX C

ECONOMICS - SOME CONCEPTS OF VALUE

The usual discussion of the value of water is involved with defining the value of an incremental quantity of water that is added to the supply. This additional quantity has a "marginal value" to the user, but there are several types of users, each "willing" to offer a different "price" for the water. An example of the range of value of water in different uses might be inferred from the following table which shows a portion of the potential addition to gross product of the region studied by different uses of water.

SOME COMPARATIVE VALUES
Value Added Created by Water Availability [13]

Type of Use	Average "Value Added" [14] $/Acre-Foot
Agriculture	$44 to $51
Recreation	$212 to $307
Industry	$3,040 to $3,989

Unfortunately, there is no easy way to value water as the procedure that gave the numbers above involves a number of assumptions that cannot be directly translated for another study. Water might be valued in at least three ways:

1. The Market Valuation. Where value is defined by a price determined (ideally) by supply and demand forces. However, there is a multiplicity of forces that exist in the "water market" and an idealistic market solution is not typical. The price that consumers pay for water might be considered as their minimum valuation of water, hence market price is an approach to valuation.

There are several components of the water price, which may vary substantially in different areas: (a) the cost of raw water, (b) treatment costs, (c) transmission and distribution costs, and (d) a subsidy or profit margin. Typical "retail" water prices are usually a function of quantity purchased, as shown in the following table:

RETAIL PRICES OF WATER IN AMERICAN CITIES
Publicly-Owned Utilities Only
(Prices in Dollars per Acre-Foot) 15/

Quantity Purchased per Month		Rate for Monthly Use Dollars/Acre-Foot		
Cu. Ft.	Acre-Ft.	Minimum	Maximum	Median
1,000	0.023	$29.62	$326.70	$108.90
10,000	0.23	18.86	193.84	80.37
100,000	2.3	15.46	142.62	54.89
1,000,000	23.	7.01	139.70	44.00

The variation in prices for water might be interpreted to mean that consumers are somewhat indifferent to water prices if water prices are low relative to other goods they purchase. Climatological conditions and socio-economic factors are probably more important than price in determining water use. Availability of water and quality may have some effect on particular uses.

A water price, once established, tends to become a "target" to evaluate the costs of supplying additional water. 16/

2. The Imputed Value Approach. The consumer defines the value of water by what he is willing to pay for water. The consumer is assumed to be able to pay for water in proportion to what the water will earn as a factor in production (as in industry or agriculture) or what resources he will trade to

consume water (as the homeowner who exchanges money for water). This latter valuation corresponds directly to the market situation. The concept of water as a productive resource can be considered from the viewpoint of rent theory, or as a factor sharing in the benefits of production. Since water takes a role in production decisions, its "rent value" in a productive use might be calculated as the residual return after other factors, such as labor and capital, receive their share. This "rent value" exceeds the market price for water, except at the point where the productive ability of water (in creating income) is equal to its price (or to use the economists' jargon, price equals marginal productivity). If we consider water as a productive resource, and when used in combination with other factors, we can get a marketable product, then we can associate some value with the water.

An example would be the use of water for irrigation, where the combination of land, weather, fertilizer, water, etc. creates a saleable product. Without the water, a lesser yield from the land would be expected. Clearly, then, water has created some extra product and the increment of product value comparing the irrigation and non-irrigation situations represents a value-added to the production of the land by the additional water. But value-added is not the same as the value of this additional water, for the additional production may need more farm implements, more investment of both money and time. These must be deducted from the value-added figure before we can calculate what we could "afford" to pay for the additional water and still cover all costs of using that water for production.

Hence, value-added figures (as shown in Part 1) are numbers which are larger than the actual value of water, possibly much larger. If we assume that 80 percent of the value-added represents before-tax "out-of-pocket" costs, then we can get the following "gross user income" figures, using the previous value-added figures.

GROSS USER INCOMES
(Before Taxes)

Type of Use	Average "Gross User Income" ($/Acre-Foot)
Agriculture	$8 to $10
Recreation	$42 to $61
Industry	$610 to $800

This "gross user income" can be divided into three portions: (a) a minimum necessary return to the investor to keep capital in this particular use, (b) taxes, and (c) a residual amount that represents the maximum amount of the income that can be offered for the water. These residual calculations above represent average rather than incremental income.

Calculating that part of these "gross user incomes" which might be secured as a rent for use of the resource represents an approach to imputing the value of water in alternative uses. These imputed values might be altered to reflect socially desirable objectives through a price subsidy, or political allocations of water.

The imputed value of water represents a maximum value of water, based on an "ability to pay" criterion. The market price tends to form a minimum value. These observations are generalizations and should be qualified with respect to the quantities required by the various users, price elasticity of demand effects, and many other factors.

3. Value Determined by Cost. In a perfectly functioning market, the value of a resource would be that price where the incremental "cost" of using the resource is equal to the incremental production of value by additional use of

the resource, the marginal value concept again. This productive value of the resource would be measured as its "imputed value" as explained in Section 2. The cost of using the resource would include the price paid for the resource.

Total costs of using the resource will be less than the productive total value of the resource if we are managing resources for efficiency. Hence, for the usual situation in resource management, we could assume that the cost of supplying the resource forms a "floor" for the value of the resource.

This is the assumption that is often used in valuation of water for planning purposes. This technique for valuation is commonly extended to define the value of a resource as being determined by the least alternative way of supplying this same resource. The least cost-alternative valuation depends upon the assumption that the resource supply created by the alternative project can be sold at a price equal to the cost of creating the supply.

Defining the value of water as the cost of creating and supplying a quantity (and quality) of water is a conservative approach for valuing water used for municipal and industrial use, but may result in values for irrigation that exceed the imputed value or ability to pay of the irrigators.

The techniques used for valuation of water that were suggested above would "ideally" result in the same value. The inquisitive reader may ask what different answers will result from applying each method. The imputed value method is a procedure for tracing out the demand schedule or "ceiling" value. The cost method traces out an approximately supply schedule, the "floor" to value. The intersection of the demand and supply schedules is the "competitive market" value for a commodity. Because the water market is imperfect, we cannot identify the equilibrium point (where supply equals demand) with preciseness; however, we have a possible procedure for "bracketing" the value of water

between a high and low value.

That the value of water varies with different uses and different quantities of use is evident. But there are many unanswered questions along this extension of thought.

Given a group of consumers with a satisfactory, though limited, water supply, what value would they attach to an additional quantity of supply? Probably less value than they now attribute to their present supply (although exceptional examples may occur, such as an increase in water allowing a new and more valuable type of farming to be possible). If this new quantity of water were offered to a new set of consumers (say, a new irrigation project) then the new users may be able to outbid the present users for the additional argument. Clearly, it is seen that the value varies here according to whether the use of the new water is to intensify present use, or to extend to new users. This notion has an application in valuing a new supply of water. If we assume that the present users want to increase their "per capita consumption" and also that there will be an increase in using population, then very possibly there will be different values for the "present user - more use or intensive use" and the "new user" or extensive use situations.

Some other distinctions among users might be between consumptive and non-consumptive uses, competing or complementary uses and necessary quality-quantity requirements.

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1. State of California, State Water Resources Board Bulletin No. 5, "Santa Cruz - Monterey Counties Investigation", August 1953.

2. ibid, page 82.

3. ibid, page 102.

4. ibid, page 102.

5. Letter Report dated February 14, 1962 from Brown & Caldwell, Consulting Engineers, to Santa Cruz Water Department.

6. Bulletin 5, Op. cit., page 82.

7. ibid, page 102.

8. Brown & Caldwell, Op. cit.

9. USDHEW, PHS, Publication No. 775, Volume 9, "Municipal Water Facilities, Inventory as of January 19, 1958", 1960.

10. Bulletin 5, Op. cit.

11. The population estimate by Brown & Caldwell, Consulting Engineers, shows 16,000 people in water company service area. The Corps' more extensive study shows 16,200 people in a much larger area. Since the water companies' service area does not cover all of the coastal plan, and none of the interior area, the population estimate for the service area was reduced slightly.

12. East Bay Municipal Utility District, Oakland, California, Annual Report Fiscal Years 1958-59, 1959-60 and 1960-61, Sanitary and Distribution Section, Water Production and Distribution Division, Engineering Department. A significant portion of this mineral increase may be due to local storm flow into the reservoirs.

13. Nathaniel Wollman - The Value of Water in Alternative Uses, Albuquerque, N. M., University of New Mexico Press, 1962.

14. Value Measured as Sum of Primary Value Added Plus Value Added by Purchase.

15. Harris F. Seidel and E. Robert Baumann, "A Statistical Analysis of Water Works Data for 1955", Journal of American Water Works Association, XLIX (December 1957), 1548.

16. A discussion of water pricing and economics, which supports the Market Allocation Viewpoint, is found in Hirschleifer, DeHaven & Milliman, "Water Supply, Economics, Technology, and Policy", Chicago University of Chicago Press, 1960.